Surveys for Desert Tortoises in the Jawbone-Butterbredt Area of Critical Environmental Concern, Eastern Kern County, California

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EXECUTIVE SUMMARY

We conducted a survey over three years (2002 to 2004) for desert tortoises (*Gopherus agassizii*) in the 759-km^2 Jawbone-Butterbredt Area of Critical Environmental Concern (ACEC) and Red Rock Canyon State Park (RRCSP) as part of a collaborative landscape management project between the Bureau of Land Management (BLM), the United States Geological Survey (USGS), and California Department of Parks and Recreation (CDPR). The objectives were to establish baseline data for tortoise populations in the ACEC and RRCSP, to develop a survey protocol for desert tortoises in areas with off-highway vehicle (OHV) recreation, and to collect data on historical and recent human impacts in the area. The study area was stratified by habitat type and type of human use. A systematic random sampling design was used to select 1-hectare plots for the survey. These plots comprised 4% of the area sampled (181 km^2 in the ACEC and 7 km^2 in RRCSP). Each plot was searched twice for live tortoises and tortoise sign (burrows, scats, shell-skeletal remains, tracks). Data also were recorded on signs of livestock use, mining, shooting, OHV use, and trash. Signs of tortoises observed while the biologists were walking to or from plots were also recorded. Tortoise sign was found on 35 (4.7%) plots. Most plots with tortoise sign were clustered in two areas. The first group of plots (N = 10) was within RRCSP and the BLM-managed land directly west of the State Park, where one live tortoise, 17 cover sites, 27 scat locations, and remains of 9 tortoises were observed. The second group of plots (N = 19) with sign was primarily within a 14 km^2 area west and adjacent to Robbers Roost and in the foothills of the Scodie Mountains: 4 live tortoises, 38 cover sites, and 109 scat locations were recorded. We

estimate that ~50 adult tortoises are present in the Kiavah Apron and ~100 adult tortoises remain in the Red Rock area.

Signs of human-related disturbance were found on every plot. The most prevalent sign was livestock scat, which occurred on 97% of the plots, followed by trash on 58% of the plots. Vehicle tracks and bullet casings were found on 52% and 37% of plots, respectively. Most vehicle tracks (92%) were from unauthorized use. Evidence of mining occurred on < 1% of the plots. The two tortoise populations that we identified were located in regions with significantly lower cattle scat (Red Rock) or significantly lower vehicle use (Kiavah Apron) than other parts of the study area ($p < 0.05$). The study area has a long-history of human activities dating back to the mid-1800s. The present-day low densities of tortoises probably result from many years of multiple human uses.

INTRODUCTION

In 1980, the Bureau of Land Management (BLM) published the *California Desert Conservation Area Plan* (BLM, 1980). One of the designated wildlife management areas was the Sierra-Mojave-Tehachapi Ecotone, identified as having special wildlife habitat, state-listed species and other species of concern. Wildlife management prescriptions included designating the Jawbone-Butterbredt Area of Critical Environmental Concern (ACEC) (Fig. 1), and preparing a Sikes Act habitat management plan. Designation of the ACEC and the management plan were completed in 1982 (BLM, 1982). The resource values identified for the ACEC were wildlife and Native American values (BLM 1980, 1982, 1999). Management actions for immediate implementation included control of vehicle use, establishment of a cooperative agreement with the private landowner, increased surveillance, and restrictions on camping and parking. The long-term goals were to change livestock grazing practices, protect water sources, and protect, stabilize and enhance fish and wildlife resource values.

The BLM manages most of the ACEC as a “limited use” off-highway vehicle (OHV) area, where the management prescription is to “allow vehicle use on approved routes only”. Within the ACEC are two “open riding” areas, the Dove Springs OHV Open Area and the Jawbone Canyon OHV Open Area, where OHV riders are permitted to drive, park, and camp without restrictions. Red Rock Canyon State Park (RRCSP), managed by the California Department of Parks and Recreation (CDPR), borders the southeastern portion of the ACEC.

Between 2001 and 2004, the BLM, U.S. Geological Survey (USGS), and CDPR jointly collected and analyzed baseline data on desert tortoise populations and habitat in the ACEC and RRCSP. For the BLM and the State of California, the long-term goals are to protect desert tortoises under provisions of the Federal Endangered Species Act of 1973, as amended, and the California Endangered Species Act. The desert tortoise was listed as a threatened species by the State of California and the U.S. Fish and Wildlife Service (USFWS) in 1989 and 1990, respectively (California Code of Regulations; USFWS, 1990). The ACEC is west and outside of the federally designated critical habitat for the desert tortoise (USFWS, 1994) and is also outside designated recovery areas.

Desert tortoises present a challenge to sample at any time, because they spend much of their lives underground in cover sites (Nagy and Medica, 1986), and their activity levels are reduced during drought (Duda et al., 1999). In addition, juveniles can be difficult to see and sample (Morafka, 1994), although these small tortoises were frequently found in mark-recapture surveys of long-term study plots during the late 1970s and early 1980s (Berry, 1986a). The challenge becomes even greater when densities are low, at the level of < 8 km^{-2} estimated 20 years ago for the Indian Wells Valley, near Jawbone-Butterbredt ACEC and RRCSP (Berry and Nicholson, 1984). Establishing a cost-effective baseline and monitoring program for tortoise populations at a landscape scale is especially difficult at low densities. Methods for studying rare populations have been discussed in the literature (e.g., McArdle, 1990; Rosenberg et al., 1995; Thompson et al., 1998). The USFWS currently supports distance sampling as a means of tracking trends in density of large immature and adult tortoises in critical habitat (Anderson et al., 2001; Buckland et al., 2001), an effective method when population densities are moderate to high (e.g., McLuckie et al., 2002). (KB-add ref PDF file) The distance sampling method is limited to data on density, and does not yield information on other population attributes (e.g. health, causes of mortality) or habitat condition.

Our survey had multiple objectives, specifically to: (1) collect baseline data on the current population and health of desert tortoises in the ACEC and the western part of RRCSP; (2) establish a protocol for ongoing monitoring of desert tortoises in areas with low population densities and also in areas designated for OHV use; (3) evaluate different parts of the ACEC for tortoise habitat suitability based on geomorphology, topography, vegetation, and intensity of human use; and (4) identify significant correlations between status and trends in tortoise populations and different types of human use. A long-term objective is to determine how management of the ACEC affects tortoise population trends.

METHODS

Study Area

The Jawbone-Butterbredt ACEC is located in Kern County, California, at the southern end of the Sierra Nevada and on the western edge of the Mojave Desert. The 759-km^2 (293 mi^2; 187,486 acres) area is bordered by California Highways 178 and 14 on the north and east, respectively (Fig. 1). The ACEC extends west into Kelso Valley, and the southern border is just south of Jawbone Canyon. Elevations range from 650 m at the extreme southeast border to > 1800 m at Mayan, Gold and

Butterbredt peaks in the Scodie Mountains, which extend north-south through the ACEC.

The wide range of elevations contributes to the diversity of vegetation. Piñon-juniper woodlands (*Pinus monophylla* and *Juniperus occidentalis*) are found at the higher elevations. At mid-elevations, plant communities include Joshua tree woodlands (*Yucca brevifolia*), blackbush-dominated areas (*Coleogyne ramosissima*), and mixed scrub communities with hop-sage (*Grayia spinosa*), California buckwheat (*Eriogonum fasciculatum*), Mojave aster (*Xylorhiza tortifolia*) and Anderson's box thorn (*Lycium andersonii*). The valleys and alluvial fans at lower elevations are generally dominated by creosote bush (*Larrea tridentata*) and burro-weed (*Ambrosia dumosa*). Distribution of the different communities is affected by topography, slope, aspect, surficial geology, and soil types.

Data on Historical Use of the Study Area

To determine the history of land use, W.T. Chambers and Nöel Stephens collected data from BLM cadastral survey records, master title plats, books, newspaper and magazine articles, and personal interviews.

Design of Surveys

The study area was divided into 5 regions (Indian Wells, Kiavah Apron, Blackbush, South Dove Springs, Red Rock) that reflect differences in geomorphology, topography, and vegetation (Fig. 2). The Indian Wells region (950-1000 m) is the flat bajada, dominated by creosote bush scrub, that lies south of Highway 178, north of BLM Route SC192, and between the Los Angeles Aqueduct access roads on the west and Highway 14 on the east (Fig. 1). The Kiavah Apron region (1050-1500 m) is the sloping foothills and canyons of the Scodie Mountains east of the Sierra Nevada crest, south of Highway 178, west of the Los Angeles Aqueduct access roads, and north of Horse Canyon. The Blackbush region (1050-1500 m) lies east of the crest of the Sierra Nevada, south of Horse Canyon, west of the Los Angeles Aqueduct access roads, and north of Dove Springs OHV Open Area. The South Dove Springs region (1000-1300 m) is east of the checkerboard of land ownership (where square mile sections of public land alternate with square mile sections of private land), south of Dove Springs Canyon, and northwest of the Red Rock Canyon watershed. It has complex topography with many small, steep-sided drainages. The Red Rock region (750-1000 m) lies within the Red Rock Canyon watershed and includes land managed both by the BLM and RRCSP.

The survey plots (100 m x 100 m, or 1 ha) were selected using a systematic random sampling method. First, the entire ACEC was divided into 500 x 500 m "quadrats," the boundaries of which were oriented north-south and east-west (Fig. 2). Each quadrat was assigned a unique 6-digit alpha-numeric code. We applied the following criteria to all quadrats: (1) < 50% of the quadrat was within 500 m of a paved road, aqueduct pipeline, utility transmission line, or accompanying utility access road; (2) ≥ 50% of the quadrat was managed by BLM or cooperating agencies; (3) ≥ 50% of the quadrat was within the ACEC or RRCSP; (4) < 50% of the quadrat was within a designated "OHV open area" (Jawbone Canyon OHV Open Area or Dove Springs OHV Open Area); and (5) the average elevation of the quadrat was < 1500 m. Quadrats that did not meet the 5 criteria were eliminated. We also eliminated (6) all quadrats west of the crest of the Sierra Nevada and (7) all quadrats in the checkerboard area. Total excluded land was 578 km^2 (223 mi^2) or 76.2% of the ACEC (Table 1). Criteria 1, 4, 5, and 6 were applied to focus the survey on areas with a greater likelihood of finding tortoises. Criteria 2, 3, and 7 were applied for legal and logistical reasons.

Within quadrats that met the 7 criteria, one 100 m x 100 m plot was randomly chosen. Once the plots were chosen, a similar set of criteria was applied to the plots: (1) each plot was > 500 m from paved roads, aqueducts, utility transmission lines, or accompanying utility access roads; (2) the entire plot was managed by BLM or cooperating agencies; (3) the entire plot was within the ACEC or RRCSP; (4) the entire plot was outside a designated open area; (5) the entire plot was < 1500 m in elevation; and (6) the maximum slope of the plot was < 45°. Plots that did not meet these criteria were eliminated. Additionally, a plot was eliminated if the field biologists, upon visiting the plot, decided that rough terrain made surveys unsafe. Eliminated plots were not replaced by other plots. Of the 181 km^2 in the non-excluded areas of the ACEC, 4% were sampled with 751-ha plots (Table 1, Fig. 3). Each plot was located using a Trimble GeoExplorer3 Geographic Positioning System unit, and the 4 corners of the plot were temporarily marked with 2.5-m flagged poles.

<u>Collection of Data on Tortoises</u>

Historical Records. Mark Faull of RRCSP and Jeff Aardahl and Robert Parker of the BLM provided records of desert tortoise observations. We searched the BLM files for data.

Training of Field Biologists. All individuals walking transects for desert tortoises successfully completed the Desert Tortoise Council's 2-day lecture and field course on desert tortoises; a 2-day laboratory course on recognizing and processing desert tortoise shell-skeletal remains; and special field training on locating wild tortoises, recognizing sign (cover sites, scats, tracks, etc.), and processing desert tortoises.

Fieldwork. Fieldwork was conducted in summer and fall of 2002 and 2003 (June 5-October 15, 2002 and July 9-September 18, 2003) and from spring to fall of 2004 (April 12-September 14, 2004). The fieldwork was primarily in the summer to maximize the collection of data on desert tortoise sign. Work began at sunrise, and continued until noon. Two field biologists searched each plot at the same time using 10-m wide transects: one person walked north-south, and a second person walked east-west. Both field biologists searched for live tortoises, signs (scats, tracks, cover sites, and other sign), and shell-skeletal remains.

Data gathering for live tortoises followed a standard protocol (Berry and Christopher, 2001). Briefly, tortoises were marked with a unique number, weighed, carapace length at the midline (MCL) was measured, sex was determined, and a health assessment was recorded. Attention was given to clinical signs of disease, such as upper respiratory tract disease (URTD) caused by *Mycoplasma agassizii* or other *Mycoplasma species*, herpes virus, and shell diseases (Jacobson et al., 1991, 1994; Brown et al., 1994; Homer et al., 1998; Berry and Jones, 2004). Observations were also made on habitat and behavior. Tortoises seen during walks to, from, and between plots were processed as described above but recorded as "off plot".

Shell-skeletal remains were photographed, examined for any evidence of the cause of death, and then collected following a standard protocol after Berry and

Woodman (1984a) and Woodman and Berry (1984). Scats of tortoise predators, in particular coyotes (*Canis latrans*) and kit foxes (*Vulpes macrotis*), were also checked for remains of desert tortoises. The field biologists determined the size and sex of the tortoise (when possible), the estimated time since death in 4 categories (< 1 yr, 1-2 yrs, 2-4 yrs, and > 4 yrs), and made a preliminary assessment of the potential cause(s) of or contributor(s) to death.

Cover sites, defined as burrows, caves, pallets, and rock shelters used by tortoises (Burge, 1978), were measured and photographed. They were assigned to 1 of 5 classes: (1) excellent condition, currently active – fresh tracks or plastron marks evident; (2) excellent condition, active and clean – tortoise can walk into and use cover site without excavation, probably used within last year; (3) good condition – plant debris or drifted sand present, tortoise could walk or plow into it and use it immediately; (4) disused/fair condition – some excavation necessary, signs of structural degradation occurring at corners of burrow opening and at mouth; and (5) poor condition – abandoned, collapsed, a major excavation effort necessary for use.

Tortoise scats were measured, and the age of each was recorded using 3 age classes: (1) within this season – slick, coated with shiny substance, dark brown or black in color; (2) within last year – dull surface, no longer shiny, or smooth, lightened in color to straw, greenish, yellow or light brown, often with pieces of vegetation protruding; and (3) > 1, probably > 2 yrs old – surface rough with vegetation protruding (pale yellow, beige, or whitened or grayish in color).

Collection of Data on Human Impacts

Field biologists surveyed each plot for old and recent evidence of human-related disturbances including, but not limited to: roads, trails, vehicle tracks, fences, trash, livestock scat, signs of shooting (firearm casings or targets), and evidence of mining. With the exception of livestock scat, both field biologists tallied these impacts separately and compared results when they finished the plot. Only one person tallied cow patties, because cow patties were ubiquitous throughout the study area, often in high concentrations. Cow patties also deteriorate and break into pieces over time, making determination of the number of original scats difficult or impossible. Therefore we defined a single cow scat as all pieces of scat within a 0.3-m (1-foot) radius. All human disturbances were recorded on standard data sheets.

Analysis of Data

For the analysis, we mapped distribution and relative abundance of live tortoises and other tortoise signs, as well as the most common human-related impacts. We evaluated the findings by region. We calculated the mean number of adult tortoises per plot for the study area as a whole and for those subregions where tortoise sign was found. We used these means and their 95% confidence intervals to estimate densities (tortoises km^{-2}) and total numbers of adult tortoises (Scheaffer et al., 1990). We compared findings with studies of populations with low densities elsewhere in the Mojave Desert. We used logistic regressions (LogReg) to test whether the presence of tortoise sign on plots was dependent on the amount of OHV tracks, livestock scat, trash, and evidence of shooting (bullet casings and targets) (SPSS Inc., 1998). We also analyzed differences in the amount of human impacts in different regions using analysis of variance (ANOVA) with the Tukey pairwise comparison post hoc test

(TPC). Because of the skewed distribution of the human impact variables, we used a square-root transformation of those data to perform the statistical tests.

RESULTS

Historical Use of the ACEC

The ACEC has been an arena for human activity since the mid-1800s. The earliest routes of travel in the 19^{th} century traversed Walker Pass on the northern end of the study area (Gibbes, 1852; Bancroft, 1868). By the 1870s, routes were well-established from the South Fork of the Kern River and Kern River Valley south through Kelso Creek and Kelso Valley to Jawbone and Red Rock canyons (Wheeler, et al. 1879; Nadeau, 1964). Stage and freight lines ran along the eastern edge of the study area and connected southern California with mining centers to the north and east (Wheeler et al., 1879; Pracchia, 1995; Nadeau, 1964). The routes were used to transport mineral ores, agricultural products, livestock, commercial freight, and settlers.

Livestock grazing has been a part of the landscape since the 1850s when settlers arrived at the South Fork, Kern River, and Kelso valleys on the north and west edges of the study area (Boyd, 1952; Starry, 1974; Powers, 1988, 2000). Sheep and cattle driveways historically crossed the ACEC at Walker Pass, Jawbone Canyon, and in an approximately north-south direction through Red Rock Canyon along the eastern face of the Scodie Mountains and Sierra Nevada (Wentworth, 1948; Fulwider, 1963).

Major north-south surface disturbances in the 20th century included the two barrels of the Los Angeles aqueduct, power towers and associated transmission lines. The first barrel of the Los Angeles aqueduct was constructed between 1905 and 1913 (Nadeau, 1997), and was followed by an almost parallel disturbance with the second aqueduct between 1965 and 1970. As part of the logistical support for construction of the first aqueduct, the Red Rock Railroad was built through Red Rock Canyon to the Dove Springs aqueduct camp for use during only 22 months (1908-1910; Faull, undated). The first paved highway was completed in 1931 (Highway 6, subsequently renumbered 14) and stretched north-south along the east side of the Scodie Mountains and Sierra Nevada. Power towers and transmission lines lie to the west of the paved highway and reinforce the same north-south pattern of linear disturbances. In the last 40 years, OHV recreation has added another layer to the existing land uses (BLM, 1980).

Desert Tortoise Data

Historic information. During the 1950s, desert tortoises were common to abundant in Indian Wells Valley to the east and adjacent to the ACEC (Berry, 1984). Oral histories from local residents who lived in Inyokern, Ridgecrest and China Lake from the 1940s to 1960s indicate that tortoise populations were high (> 100 km^{-2}), at least locally in Indian Wells Valley some 20 km to the east (Berry, 1984). Several scientists giving oral histories placed observations of tortoise numbers in the context of time and space. By the late 1970s and early 1980s, estimates of tortoise densities, based on strip transects, were < 8 km^{-2} for Indian Wells Valley (Berry and Nicholson, 1984). For the ACEC specifically, data are available from 6 strip transects for

September 1977 (BLM, files). Each strip transect was 10 yards wide and 1.5 miles long. Three of the 6 transects had 1 - 3 tortoise signs; 5 were within 1.6 km of a major highway or graded road or within 2 to 3 km of a residence or other major disturbance.

In contrast with the low estimates of tortoise densities from Indian Wells Valley for the late 1970s and early 1980s, tortoise population densitites were high in Fremont Valley and the Desert Tortoise Research Natural Area (DTRNA), two areas that are within 16 km of the southern end of the ACEC (USFWS, 1994; Berry and Medica, 1995; Brown et al., 1999). Population densities of tortoises at the DTRNA were estimated using mark-recapture techniques at ~150 km^{-2} in the early 1980s (Berry and Medica, 1995) but had declined by > 90% in the early 1990s (Brown et al., 1999).

Although BLM biologists (Jeff Aardahl, Robert Parker, pers. comm.) have observed desert tortoises in the Jawbone-Butterbredt ACEC during the last 20 years, the ACEC has not been the focus of additional formal surveys for tortoises. At least one incidental observation was made in Kelso Valley (Robert Parker, pers. comm.) since 1994. Faull has compiled records of tortoise observations by visitors and staff from RRCSP for 1978-2003 (Berry et al., 2004). Most records are from visitor areas, e.g., Ricardo Campground, Hagen Canyon. Some may be of released pets (e.g., 09/21/1990: female at Ricardo Campground with a shell patched with fiberglass).

Data from the current study. Definitive tortoise sign was found on 31 (4.1%) of 751 plots; an additional 4 plots had old sign that may have belonged to tortoises or to another species (Fig. 4). The plots with tortoise sign were primarily clustered in 2 parts of the study area: (1) the Red Rock area (10 plots), both inside the State Park and on the BLM-managed land directly west of the State Park (Table 2); and (2) the Kiavah Apron (19 plots), within a ~14 km^2 area west of Robbers Roost in the foothills of the Scodie Mountains. Two plots in the Indian Wells region and 4 plots in the Blackbush region also had tortoise sign or possible tortoise sign. Walking between plots, the field biologists noted additional tortoise sign, which was found exclusively within the Kiavah Apron and Red Rock regions (Table 3, Fig. 5). Although the sign in the Kiavah Apron region was concentrated within the 14 km^2 area, a cover site (in good condition) was found ~3 km to the north (Fig. 5). At Red Rock, the extent of the area with tortoise sign has not been delineated because of private lands to the west, steep topography that prevented systematic searches, and the low-density of the sampling design.

Four live tortoises were encountered in the Kiavah Apron region, 3 adult females and 1 adult male (Table 4). All 4 tortoises were old adults, and exhibited an advanced stage of shell-wear or aging (Berry and Woodman, 1984b). Their shells had few remaining growth rings. On the carapace, smooth, worn areas made up large portions (> 50%) of some scutes and depressions were present on up to 8 of the 13 vertebral and costal scutes. Three of the tortoises had clinical signs of URTD: swelling around the eyes (edema of the palpebra and periocular area). The nares, however, were unobstructed and no wet or dried mucus was observed on the face or forelimbs. The eyes and face of the fourth tortoise were not visible during the health evaluation and thus the assessment was incomplete. A fifth tortoise was identified inside of a burrow in the Red Rock region, but it was not evaluated because of high ambient temperatures.

Nine shell-skeletal remains were discovered, all within the Red Rock region (Table 5). Six shells were of adult tortoises: 1 male, 1 female, and 4 of unknown sex. Five of the adults had been dead > 4 years, and evidence was insufficient to assign a cause of death. The other adult had been dead about 4 yrs and had chew and puncture marks typical of a carnivore predator, indicting that the tortoise may have been killed or scavenged. The 3 juveniles had been dead < 4 yrs, and one showed signs of avian predation, probably by a common raven (*Corvus corax*).

Of the 61 cover sites observed (Table 6), most (50) were in good or excellent condition (classes 1-3). Twelve of the cover sites, 11 within the Kiavah Apron region and 1 within the Red Rock region, showed evidence of recent use by desert tortoises. While 66% of the cover sites in the Kiavah Apron region were in excellent condition (classes 1 and 2), only 29% of the cover sites in the Red Rock region were in excellent condition. In the Blackbush region, 4 cover sites were identified, 2 of which were in good or excellent condition. The only cover sites found in the Indian Wells region were collapsed burrows in poor condition (class 5).

Tortoise scats were found almost exclusively in 2 regions: 109 locations in the Kiavah Apron region and 26 locations in the Red Rock region (Table 7). There was 1 scat location in the Indian Wells region. Scat at 73% of these locations was probably < 1yr old (classes 1 and 2), and 41% had probably been deposited within the previous 6 months (class 1).

We estimated densities of 3.6 adult tortoises km^{-2} (95% confidence interval [CI] = $\pm$5.0) for the area within the Kiavah Apron region and 2.7 adult tortoises km^{-2} (95% CI = $\pm$5.5) for the Red Rock area (Table 8). Tortoise sign in the Kiavah Apron area was in a concentrated area, and we estimated that 50 adult tortoises (3.6 tortoises km^{-2} x 14 km^{2}) may live in the local area (95% CI = 4-121). Tortoise sign in the Red Rock area occurred over a larger area, ~40 km^{2}, and using the same method, we estimated that 108 adult tortoises may be present (95% CI = 1-328). Because both of these population estimates are based on highly skewed data (only 3 plots had live tortoises), the confidence intervals are quite large~~results are approximations~~.

Human-related Impacts

The results of surveys for signs of human-related disturbances revealed widespread human activities throughout the study area (Table 9; Figs. 6-9). The most prevalent sign was livestock scat, found on 97% of the plots. It was only absent on plots in and around RRCSP, 3 plots in the South Dove Springs region and 1 plot with very steep terrain in the Scodie foothills. Trash, often tin or aluminum cans, occurred on 58% (N = 436) of the plots. Fifty-two percent (N = 388) of the plots had vehicle tracks, either 4-wheel drive or motorcycle or both. Although a few of the tracks were on designated OHV routes, most tracks (92%) stemmed from cross-country travel on unauthorized routes. Shooting was also a widespread activity: 37% of the surveyed plots (N = 278) had bullet casings. Evidence of mining, on the other hand, occurred on < 1% of the plots (N = 4).

Each of the 4 most common human impacts was significantly higher in some of the regions and lower in others (TPC, $p < 0.05$) (Table 10). Cattle scat was lower in the Red Rock region than in each of the other regions, and it was lower in the South Dove Springs region than in both the Blackbush and Indian Wells regions (Fig. 10). The amount of trash was higher in the Red Rock and Indian Wells regions and lower in the Blackbush and Kiavah Apron regions (Fig.12). The number of vehicle tracks was higher in the South Dove Springs and Indian Wells regions and lower in the Kiavah Apron and Blackbush regions (Fig.13). Another important pattern of OHV use is the high amount of unauthorized OHV use adjacent to and outside of the Dove Springs Open Area: three times as many tracks were on the 42 plots within 3 km of the northern edge of the Open Area compared with other plots in the Blackbush region (ANOVA, $p < 0.0005$, $F = 42.5$, $df = 390$). Finally, evidence of shooting was significantly higher in the Red Rock region than in the Indian Wells region.

The pattern of impacts is thus different for each of the regions. The Indian Wells region tends to have more human impacts (with the exception of shooting) than other regions. At the other end of the spectrum are the Blackbush and Kiavah Apron regions with generally lower amounts of impacts. The Red Rock region stands out because of its much lower amount of livestock scat, but it does have higher amounts of shooting and trash. The South Dove Springs region had the greatest number of vehicle tracks but was moderate in terms of the other impacts.

Analysis of Human-related Impacts in Relation to Tortoise Sign

Plots with tortoise sign had significantly fewer livestock scats than plots without tortoise sign. Specifically, there were almost 100% more livestock scats on the plots without tortoise sign than on plots with tortoise sign (Table 11). The presence of tortoise sign was dependent on the amount of livestock scat for all the plots in the study area (LogReg, $p < 0.0005$) as well as for plots only within the Kiavah Apron region (LogReg, $p = 0.011$).

On average, twice as much trash and evidence of shooting was observed on plots without tortoise sign as was observed on plots with tortoise sign (Table 11). The average number of vehicle tracks was slightly higher on plots with tortoise sign. However, the regressions did not indicate that the presence of tortoise sign was dependent on shooting (LogReg, $p = 0.750$), trash (LogReg, $p = 0.596$), or vehicle use (LogReg, $p = 0.403$).

DISCUSSION

Desert Tortoise Populations

Our study provides the first systematic survey of the Jawbone-Butterbredt ACEC and RRCSP for desert tortoises (see also Berry et al., 2004). No other baseline data exist for distribution and densities of tortoises prior to 2002-2004, other than the desert-wide strip-transect survey conducted between 1977 and 1984 (Berry and Nicholson, 1984). We have no quantitative data to directly compare with our data sets for this study. Oral histories and data sets from nearby areas provide valuable clues of what populations might have been present in the 1950s and 1960s after numerous human activities were underway (Berry, 1984; Berry and Medica, 1995; Brown et al., 1999).

By the late 1970s and early 1980s, densities were estimated at < 8 tortoises km^{-2} (Berry and Nicholson, 1984), similar to what we found with a 4% sample. When the Jawbone-Butterbredt ACEC data are compared with data sets from other, larger plots with low densities at RRCSP and at Goldstone Deep Space Communication Center (Table 12, Berry et al., 2004; in preparation), the findings are similar for counts of live tortoises km^{-2}, tortoise cover sites km^{-2} and tortoise scats km^{-2}.

There are two concerns with our population estimates. While we are 95% confident that the density is < 8.6 tortoises km^{-2}, we do not know the exact density nor how many tortoises are present. The number of tortoises found on the plots was simply too low for a more accurate assessment. Also, because the field work was done almost entirely during the summer when juvenile and immature tortoises are less active, our results do not include this important part of the population. A solution to both these problems would be to do an intensive mark-recapture study during the spring in the areas in which we found tortoise sign.

We chose the 1-ha quadrats for sampling tortoises and human-related impacts because we thought the method might produce more detailed population and habitat data on a landscape level than would other techniques such as the 2.6 km^2 study plots (Berry and Medica, 1995) and distance sampling (Buckland et al., 2001). Using the 1-ha quadrat method, 2 areas with concentrations of sign were identified, the Kiavah Apron and Red Rock regions. We must be cautious about drawing conclusions that only two concentration areas exist, because so few live tortoises and shell-skeletal remains were found and because of the 4% sample size. The presence of tortoise sign in the Blackbush and Indian Wells regions indicates that these areas may have individuals or clusters of individuals.

We do not know whether viable desert tortoise populations exist west of the Sierra Nevada crest within Mojave Desert ecosystems or in the watersheds of the South Fork of the Kern River or Kelso Creek. Nevertheless, we can say that densities in areas we surveyed are very low, populations appear to be fragmented, and the current individuals may represent the remnants of a former, widespread and high density population present in the Fremont and Indian Wells valleys before the advent of multiple human uses.

Although all of the tortoises we found were older individuals with an advanced state of shell-wear, we do not believe that the populations here are senescent. Almost all of the fieldwork was done in the summer when juvenile and immature tortoises are less active than their adult counterparts. The smaller size of juvenile and immature tortoises also makes them more difficult to find (Morafka 1994; but see Berry, 1986a). In addition, younger tortoises *were* found in the Red Rock region in 2004 as part of a different survey (Berry et al, 2004).

Information about the current population and health of desert tortoises in the ACEC and the western part of the RRCSP is useful for focusing new and more intensive inventories and population studies of desert tortoises in the Jawbone-Butterbredt ACEC. Evaluating different parts of the ACEC for tortoise habitat suitability based on geomorphology, topography, and vegetation appears to be less important than getting a better assessment of the population. Drawing on the existing data base, our first priority is to concentrate sampling efforts in the RRCSP and Kiavah Apron, possibly using cluster analysis (Thompson et al., 1998). A lower, but still important, priority is to increase the sampling in the ACEC overall, including the west side of the crest of the Sierra Nevada.

Historic Land Uses

Our findings on the desert tortoise reflect the cumulative effects of the historic land use and human-related impacts. Many factors have contributed to State and Federal listings of the desert tortoise (California Code of Regulations; USFWS, 1990), including decline in populations and fragmentation, deterioration, and loss of habitat (USFWS, 1994; Berry and Medica, 1995). Historic records indicate that land use in the Jawbone-Butterbredt ACEC and RRCSP has been both diverse and continuous since the 1860s. Virtually no areas below 1500 m in elevation, where tortoises are most likely to occur, remain unaffected by one or more human activities. Although some areas > 1150 m are in designated wilderness such as the Kiavah Wilderness (per the California Desert Protection Act, 1994), cattle still graze these wilderness lands as a pre-existing land use except where terrain is too steep to permit bovine access. Below 1150 m, ~1.5 centuries of livestock grazing have been accompanied by the stock driveways; travel routes for stage coaches, freight lines, and modern-day vehicles; north-south utility lines and two aqueducts; and intensive recreation use in Jawbone and Dove Springs canyons and RRCSP. Activities at different spatiotemporal scales have fragmented desert tortoise habitat and created cumulative impacts on the landscape, with effects on vegetation, and to some extent, topography. The pattern of impacts here is similar to the southern California deserts in general (Lovich and Bainbridge, 1999), but the levels of use have been higher overall because of the close proximity of the study site to the western edge of the

Mojave Desert and its junction with the San Joaquin Valley and metropolitan Southern California.

Current Land Uses: Correlations of Tortoise Sign with Human Impact Variables

Many different human uses negatively affect desert tortoise populations and habitats. We found widespread recent evidence of livestock use throughout the Jawbone-Butterbredt ACEC. Tortoise sign was significantly lower on plots with high livestock scat counts. Livestock grazing affects tortoises through loss of shrub cover, trampled cover sites, competition for forage plants, and the degraded nutritional quality of forage (Avery and Neibergs, 1997; Avery, 1998; Jennings, 2002; Oftedal et al., 2002). Throughout much of the Mojave and Sonoran deserts, livestock grazing and other surface disturbances have altered the composition and biomass of critical forage for the tortoise: herbaceous perennial plants and winter annual herbs. Alien annual plants now compose ~65% of the biomass of the annual flora in the western Mojave Desert (Brooks, 1998; Brooks and Berry, in press).

Off-highway vehicle use contributes to mortality of tortoises as well as deterioration and loss of habitat (Bury and Luckenbach, 2002). The total length of OHV routes in the Dove Springs OHV Open Area increased from 49 km to 576 km between 1965 and 2001 (Matchett et al, 2004). This indication of intense OHV use is supported by our finding of is a high concentration of unauthorized use outside of the Open Area. Recreation pressure in general adds to pressure on tortoise populations from shooting and vandalism (Berry, 1986b). Vehicle use was lower in the Kiavah Apron region than in each of the other regions. The presence of tortoises in the Kiavah Apron (and absence elsewhere) may be related to differences in OHV use.

An important consideration in discussion of OHV use is a limitation in our study design. Because we wanted to focus limited research resources in areas with the greatest likelihood of having tortoises, we did not place sample quadrats in the Dove Springs and Jawbone Canyon OHV Open Areas, thereby removing a data set that potentially would have zero sign and high numbers of vehicle tracks. The inclusion of these areas may have provided more conclusive evidence of the negative impacts of OHV use on tortoises.

Other contributing variables to low numbers of tortoises in the ACEC are the highways and roads, disease, and predation of juveniles by ravens. Highways and roads are known to have impacts on tortoises for a substantial distance from the pavement edge (e.g., von Seckendorff Hoff and Marlow, 2002). Newly emerging diseases, such as URTD caused by one or more species of *Mycoplasma*, have contributed to population declines at the DTRNA (Jacobson et al., 1991; Brown et al., 1994, 1999) and are more likely to affect tortoises in close proximity to urban areas than in remote parts of the desert (Jacobson et al., 1995). The combination of clinical signs and close proximity to urban areas such as Ridgecrest and Inyokern, both of which have households with ill captive tortoise (Berry, unpublished data), suggest that one or more of the tortoises we examined is likely to have URTD caused by one or more species of *Mycoplasma.* Raven populations have increased 1000% since the late 1960s with a consequent increase of predation on juvenile tortoises (Boarman and Berry, 1995). Although we do not know the extent of tortoise mortality due to the vehicles, disease, and ravens in the ACEC, the numerous variables affecting populations and habitat are probably interacting synergistically to the detriment of the tortoise.

Management Implications and Recommendations

Both the Kiavah Apron and Red Rock regions have received protection recently due to Special Area status (seasonal closures to protect birds of prey at Robbers Roost; BLM, 1980, 1983) or State Park status. With the exception of campgrounds, hiking trails and vehicle routes, these areas may have received lower levels of human use and disturbance, thus conferring some protection on the tortoises. However, recent establishment of an OHV campground on private land to the east of the Kiavah Apron may bring greater impacts in the near future without compensating measures for conservation of the remnant tortoise populations.

1. The management objective by law for BLM is to ~~conserve~~maintain ~~and build~~ viable populations of desert tortoises in these two regions. Additional protective measures merit consideration, particularly protective fencing in the Kiavah Apron region. Fencing has benefited plants, lizards, birds, and mammals at the DTRNA (Brooks, 1995; 1999). By restricting or eliminating livestock use, fencing permits the recovery of perennial shrub biomass and cover (resulting in more protection for tortoises from their predators), improves the supply of annual plant species for forage, can increase the seed bank (Brooks, 1995), and reduces or eliminates trampling of cover sites and tortoises. In addition to desert tortoises, fencing will benefit other BLM Species of Special Management Concern in the Kiavah Apron region: prairie

falcons (*Falco mexicanus*), golden eagles (*Aquila chrysaetos*), and Mohave ground squirrels (*Spermophilus mohavensis*).

2. The ACEC contains two heavily used OHV areas: Dove Springs and Jawbone Canyon Open Areas. Outside of these open areas, most tortoise habitat is on land with a "limited use" status, and vehicles are supposed to remain on designated routes. Unfortunately, unauthorized use is widespread and frequent, and much of it is associated with the Dove Springs OHV Open Area and the aqueduct corridors. Increased and strict enforcement of the designated route system in combination with habitat restoration measures would enhance protection for both tortoises and their habitat.

3. Trash should be removed from the RRCSP watershed and from the Kiavah Apron, to reduce chances that tortoises will consume it (e.g., Burge, 1989). Removal of trash should also help control the population of ravens, which can be high in the Dove Springs OHV Open Area (Weigand observed high numbers after the Thanksgiving holiday in 2004).

4. The objective of establishing a baseline data set on desert tortoise populations was only partially achieved due to the low density of tortoises. More baseline data is needed in several areas. The first priority is additional work in the Kiavah Apron and RRCSP in the near future. With a focused survey, such as a cluster analysis approach (Thompson et al., 1998) or another protocol, we can get a more precise estimate for the sizes of these populations. A lower priority is to conduct intensive surveys around the scattered sign that was found in the Blackbush and Indian Wells regions to determine if tortoise populations are present. A survey for tortoises in the Kelso

Valley is also a lower priority. The checkerboard region appears to be promising habitat; it should be surveyed if arrangements can be made with the private landowner.

For future surveys, the data on human-related impacts can be improved in 2 ways. If trash is collected and weighed for each plot, a more accurate assessment of that impact is possible, and accumulation in the future can be measured. Surface disturbance can be better assessed by careful measurements of the length and width of all trails and denuded areas.

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Table 1. Sizes of areas selected for desert tortoises surveys for the Jawbone-Butterbredt Area of Critical Environmental Concern.

Area name	Size of area km^2	Size of area mi^2
Jawbone-Butterbredt ACEC	758.9	293.0
<u>Excluded areas</u>		
Aqueduct corridors	58.9	22.8
Dove Springs Open Area	14.0	5.4
Jawbone Canyon Open Area	30.9	11.9
Area west of Sierra Nevada crest	181.2	70.0
Checkerboard area	172.1	66.5
Elevations $\geq$ 1500 m	100.4	38.8
TOTAL excluded area*	578.2	223.2
<u>Sampled areas</u>		
Area sampled in ACEC	180.7	69.8
Area sampled in Red Rock	7.0	2.7
Total area sampled	187.7	72.5
Area of plots surveyed	7.5	2.9
% that plots compose area sampled	4.0	4.0

*The total excluded area is not the sum of all the excluded areas because other excluded areas (such as the buffers around the power lines and ACEC boundary, and private inholdings) are not included in this table. Note, also, that many of the excluded areas overlap, e.g., the aqueduct corridor crosses both open areas, and the area west of the crest of the Sierra Nevada includes elevations > 1500 m.

Table 2: Summary of tortoises and tortoise sign found on plots in the Jawbone-Butterbredt Area of Critical Environmental Concern.

Plots	Blackbush	Indian Wells	Kiavah Apron	Red Rock	S.Dove Springs	Grand Total
Total	392	137	154	37	31	751
No. with sign, %	4, 1.0	2, 1.5	19,12.3	10, 27.0	0,0	35, 4.7
No. with cover sites	4	1	11	8	0	24
No. with scat	0	1	18	3	0	22
No. with footprints	0	0	2	0	0	2
No. with live tortoises	0	0	2	1	0	3
No. with shell-skeletal remains	0	0	0	0	0	0

Table 3: Summary of desert tortoise sign found on and off plots in the Jawbone-Butterbredt Area of Critical Environmental Concern.

	Total sign observed																	
	Blackbush			Indian Wells			Kiavah Apron			Red Rock			South Dove Springs			Grand total		
	on	off	Tot.	on	off	Tot.	on	off	Tot.	on	off	Tot.	on	off	Tot.	On	off	Tot.
Live tortoises	0	0	0	0	0	0	2	2	4	1	0	1	0	0	0	3	2	5
Tortoise remains	0	0	0	0	0	0	0	0	0	0	9	9	0	0	0	0	9	9
Cover sites	4	0	4	2	0	2	17	21	38	10	7	17	0	0	0	33	28	61
Tortoise scats	0	0	0	1	0	1	63	46	109	10	16	26	0	0	0	74	62	136
Footprints	0	0	0	0	0	0	3	3	6	0	1	1	0	0	0	3	4	7
Totals	4	0	4	3	0	3	85	72	157	21	33	54	0	0	0	113	105	218

Table 4: Live tortoises found in the Jawbone-Butterbredt Area of Critical Environmental Concern.

ID	Date mmddyy	Sex	MCL (mm)	Weight (grams)	Notes on health
B3	07242002	F	260	2700	Some dried flaking skin around eyes; trauma noted on first and second right marginal scutes.
B11	07262002	M	290	4600	Two crushed scales on right forelimb; right and left Chin glands are swollen.
B12	06302004	F	247	2700	Some swelling of both palpebrae and periocular regions.
B13	08272003	F	225	1950	Exposed bone on following marginal scutes: L2, L8, R10.
None	06292004	This tortoise was seen in a burrow, but not processed because the temperature was too high. It was the only live tortoise seen in the Red Rock Region.			

Table 5: Shell-skeletal remains found in the Jawbone-Butterbredt Area of Critical Environmental Concern.

Date yyyymmdd	Carc. no.	Amount of remains	Est. MCL (mm)	Est. time since death (yrs)	Year of death	Sex	Estimated cause(s) of death
20020605	1	Partial shell	97	2-4	1998	Unk	Unk
20020709	2	Partial shell	197	> 4		Unk	Unk
20020715	3	Partial shell	53	1-2	2001	Unk	Avian predator
20020724	4	Entire shell	215	2-4	1998	M	Possible predator gnawing and bites
20020724	5	Partial shell	220	> 4		Unk	Unk
20020724	6	Partial shell	233	> 4		Unk	Unk
20021015	7	Partial shell	233	> 4		F	Unk
20021015	8	Entire shell	210	> 4		Unk	Unk
20040629	9	Entire shell	78	< 1	2004	Unk	Unk

Table 6: Number of cover sites by condition class in each region of the Jawbone-Butterbredt Area of Critical Environmental Concern.

Condition class	Number of cover sites Blackbush	Indian Wells	Kiavah Apron	Red Rock
1	0	0	11	1
2	1	0	14	4
3	1	0	9	9
4	0	0	4	2
5	2	2	0	1
Totals	4	2	38	17

Table 7: Number of scat locations by estimated age in each region in the Jawbone-Butterbredt Area of Critical Environmental Concern.

Code for age/recency	Number of scat locations		
	Kiavah Apron	Red Rock	Indian Wells
1	42	14	0
2	33	10	0
3	34	2	1
Totals	109	26	1

Table 8. Estimation of total adult tortoise population. The final column was calculated by multiplying the area with tortoise sign by the upper bound of the confidence interval for adult density.

	Area with tortoise sign (km^2)	Plots sampled within area	Adult tortoises / plot (95%C.I.)	95% C.I. for adult density (tortoises km^{-2})	Est. number of adult tortoises
Kiavah Apron area	14	56	0.036 ± 0.050	0 to 8.6	< 121
Red Rock area	40	37	0.027 ± 0.055	0 to 8.2	< 328
Entire study area	188	751	0.004 ± 0.005	0 to 0.9	< 170

Table 9: Most common signs of human disturbance found on plots in the Jawbone-Butterbredt Area of Critical Environmental Concern.

	Percentage of plots in each region with the indicated disturbance					
Human-related impacts	Blackbush (N=392)	Indian Wells (N=137)	Kiavah Apron (N=154)	Red Rock (N=37)	S.Dove Springs (N=31)	Total (N=751)
4-wheel drive tracks	25	13	25	22	45	23
Motorcycle tracks	39	48	30	32	52	39
Trash (general)	50	75	55	84	71	58
Bullet casings	37	31	38	54	35	37
Shooting targets	7	1	7	16	3	6
Livestock scat	> 99	100	100	43	90	97
Balloons	26	31	23	41	29	27

Table 10: Probability values for comparisons of regional differences in the amount of human-related impacts (ANOVA with the Tukey pairwise comparison post hoc test). Only those relationships with a p-value ≤ 0.15 are shown.

Human-related impact	Relationship	*P*-value	F-ratio	df
Livestock scat	Blackbush > Red Rock	< 0.0005	69.9	746
Livestock scat	Indian Wells > Red Rock	< 0.0005	69.9	746
Livestock scat	Kiavah Apron > Red Rock	< 0.0005	69.9	746
Livestock scat	S. Dove Springs > Red Rock	< 0.0005	69.9	746
Livestock scat	Blackbush > S. Dove Springs	0.003	69.9	746
Livestock scat	Indian Wells > S. Dove Springs	0.014	69.9	746
Livestock scat	Kiavah Apron > S. Dove Springs	0.094	69.9	746
Trash (general)	Red Rock > Blackbush	< 0.0005	9.0	746
Trash (general)	Red Rock > Kiavah Apron	< 0.0005	9.0	746
Trash (general)	Indian Wells > Blackbush	0.001	9.0	746
Trash (general)	Indian Wells > Kiavah Apron	0.043	9.0	746
Trash (general)	Red Rock > S. Dove Springs	0.091	9.0	746
Trash (general)	Red Rock > Indian Wells	0.124	9.0	746
Vehicle tracks	S. Dove Springs > Kiavah Apron	0.002	4.2	746
Vehicle tracks	S. Dove Springs > Blackbush	0.029	4.2	746
Vehicle tracks	Indian Wells > Kiavah Apron	0.057	4.2.	746
Shooting evidence	Red Rock > Indian Wells	0.033	2.6	746

Table 11: Comparison of the average amounts of different types of human disturbance on plots with tortoise sign to the amounts on plots without tortoise sign in the Jawbone Butterbredt Area of Critical Environmental Concern.

Type of disturbance	Average count of impacts	
	Plots with tortoise sign	Plots without tortoise sign
Livestock scat	82	165
~~Garbage~~Trash	2.2	4.0
Bullet casings and targets	1.1	2.7
Vehicle tracks	1.5	1.2

Table 12. Comparisons of data from the plots in the Kiavah Apron tortoise population and plots in the Red Rock tortoise population to data from larger areas with very low tortoise densities. Goldstone is located on Ft. Irwin in San Bernardino County, California; the data is from the spring of 1998 (Berry et al., in preparation). The data from the Red Rock Demographic Plot was collected from the State Park in the spring of 2004 (Berry et al., 2004).

Live tortoises and tortoise sign	Plots in Kiavah Apron area (56)	Plots in Red Rock area (37)	Goldstone Plot#7	Goldstone Plot#12	Red Rock Demographic Plot
Total area sampled (km^2)	0.56	0.37	1.0	1.0	4.1
Live tortoises (N)	2	1	2	6	9
Live tortoise counts km^{-2}	3.6	2.7	2.0	6.0	2.2
Cover sites (N)	18	10	30	25	74
Cover site counts km^{-2}	32.1	27.0	30.0	25.0	18.1
Scat locations (N)	63	10	> 25	> 75	39
Scat locations km^{-2}	112.5	27.0	> 25.0	> 75.0	9.5

Fig. 1: Important geographic locations within and around the study area. The only roads shown on this map are Highways 14 and 178, Kelso Valley Road, and SC192.

Fig. 2: Regions within the study area. Each block represents a 500 m by 500 m quadrat from which a 100 m by 100 m study plot was randomly chosen.

Fig. 3: Plots randomly selected to be surveyed and areas excluded from the survey (see text).

Fig. 4: Results of the search for desert tortoise sign on the plots.

Fig. 5: Tortoise sign that was found both on the survey plots and while walking between the survey plots and vehicles.

Fig. 6: Amounts of livestock scat found on each plot.

Fig. 7: Amounts of trash found on each plot.

Fig. 8: Numbers of vehicle tracks found on each plot.

Fig. 9: Numbers of shooting targets and bullet casings found on each plot.

Figure 10: Average number of livestock scats per plot, by region.

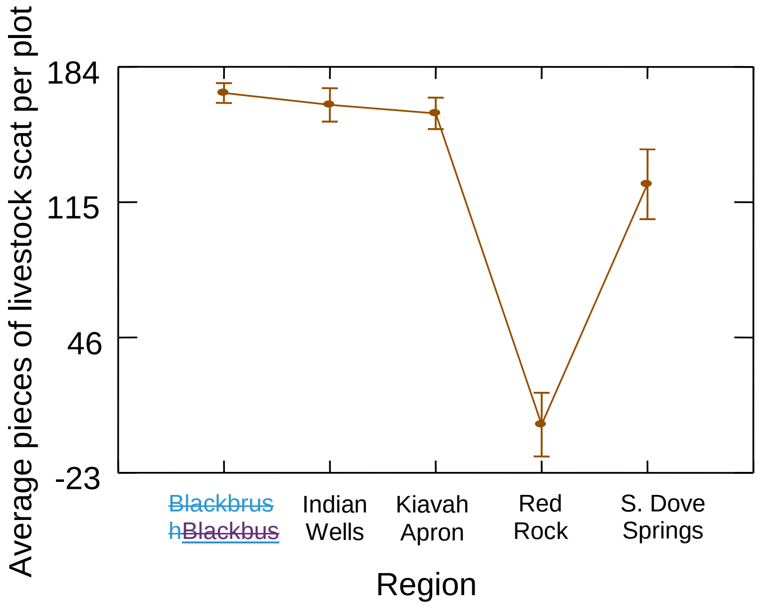

Figure11: Average number of bullet casings and shooting targets per plot, by region.

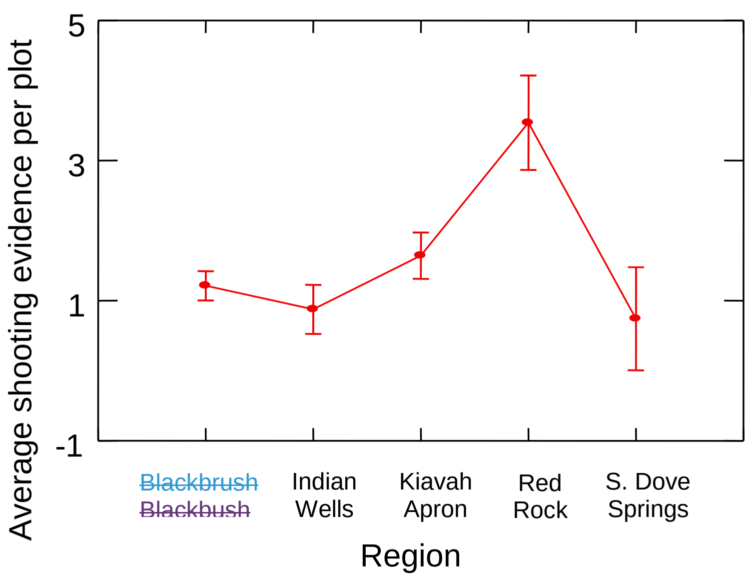

Figure 12: Average number of pieces of trash per plot, by region.

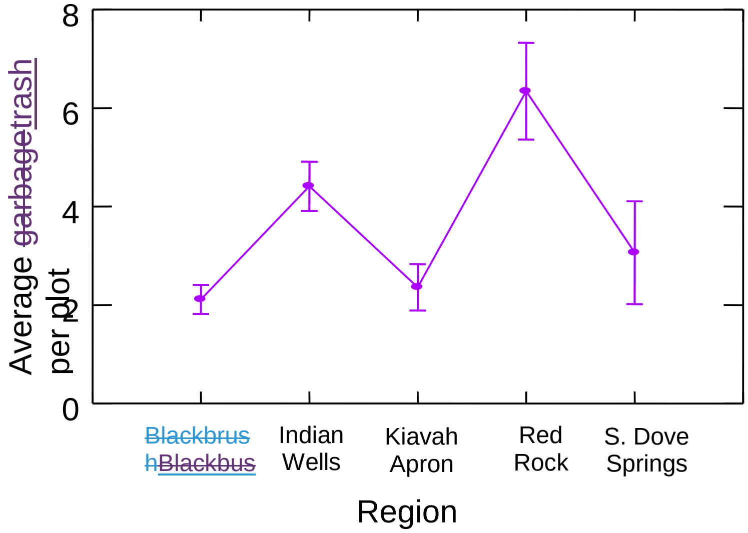

Fig 13: Average number of vehicle tracks per plot, by region.